Pedobiologia 22, 191—195 (1981)

Soil nematode populations depressed in the presence of earthworms

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With one figure

(Accepted: 05. 10. 80)

Key words: Soil nematodes, earthworms, pasture, population decrease, interaction

1. Introduction

The beneficial value of earthworms in soil is widely accepted (Satchell 1967) and in New Zealand pastures European lumbricid earthworms have been introduced to fill niches not normally exploited by the endemic Megascolecidae (Stout 1973; Martin 1978). There is a continuing programme of earthworm inoculation in New Zealand pastures, with herbage production being increased by up to 100%. Under grazed pastures soil nematode populations have been significantly, positively correlated with herbage production (Yeates 1979). This paper assesses nematode populations in the presence and absence of earthworms.

2. Soils and methods

2.1. Field trials

Tihoi sand (strongly podzolised yellow-brown pumice soil; Typic Haplorthod).

A long established worm inoculation trial in grazed ryegrass (*Lolium perenne* L.) white clover (*Trifolium repens* L.) pasture was sampled in October 1973, duplicate cores 69 mm in diameter from 0—74 mm soil depth being collected. Samples were extracted by the tray method and total counts made (Yeates 1978a). Approximately 1,000 specimens were identified to genus level. Inoculated plots contained some 4,660 earthworms/m², control plots no earthworms.

Wehenga silt loam (southern yellow-brown earth; Umbric Dystrochrept).

In March 1980 five replicate cores, each 51 mm in diameter and 10 cm deep were collected from control and worm inoculated paddocks of an area as described by Stockdill (1959) and Stockdill & Cossens (1966). After extraction, counting and mounting some 600 nematodes were identified.

2.2. Pot trial

Judgeford silt loam (central yellow-brown earth; Typic Dystrochrept).

A pot trial using subsoil (15—30 cm), with and without earthworms, was run in a glasshouse for 12 months (Hart, McColl & Cook 1981). In December 1979 pots sown with ryegrass (*Lolium perenne* L.) were sampled to 10 cm using a corer 25 mm in diameter; 1 core from each of 5 replicate pots were taken and extracted as above. Some 500 specimens were identified. For uniformity results are expressed on m² basis.

3. Results

Total nematode populations are shown in Figure 1. In every case there was a marked reduction of nematodes after earthworms had been introduced; reduction occurred in both 0—5 and 5—10 cm soil depth, where these were sampled separately.

Abundance of nematode genera is given in Table 1, and in each soil some populations changed markedly.

Tihoi sand, despite a 37% decrease in total nematodes showed marked increases in *Ditylenchus* (+120,000/m²) and *Paratylenchus* (+45,000/m²). These two genera are plant feeding and have drought-resistant stages so they are well adapted to exploit the increased productivity in this droughty soil. There was a fall in many bacterial-feeding genera (*Cepha-*

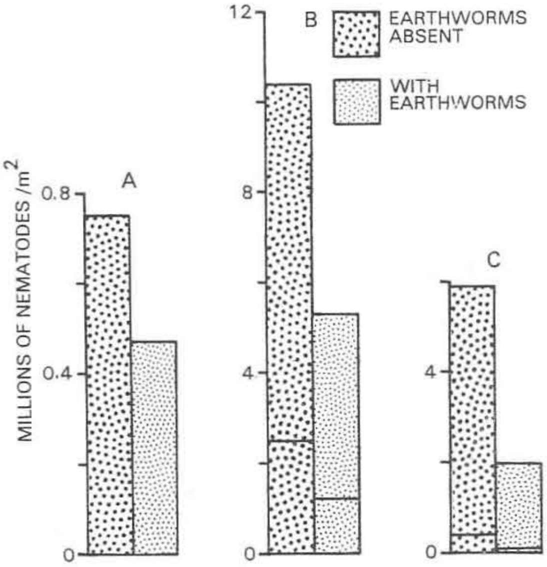

Fig. 1. The effect of introduction of earthworms on the total nematode population in: (A) grazed pasture on Tihoi sand (0—7.4 cm soil depth), (B) grazed pasture on Wehenga silt loam (0—10 cm, (C) pots of Judgeford silt loam subsoil sown wit9 ryegrass.

lobus, Plectus, Chronogaster) and bacterial feeding nematodes fell from 300,000/m² to 120,000 per m², despite increases in *Rhabditis* and *Panagrolaimus*. Among the Dorylaimida, *Dorylaimus, Tylencholaimus* and *Dorylaimellus* showed marked decreases, but *Aporcelaimus* maintained its absolute population and its percentage contribution to the fauna increased from 10% to 16%.

Wehenga silt loam in which earthworms had become established showed a 49% drop in total nematodes compared with the control paddock. While the percentage contribution of *Tylenchus* and *Paratylenchus* increased by at least 3% their absolute populations fell; *Ditylenchus* and *Pratylenchus* were the only Thylenchida to show increases. All bacterial feeding nematodes showed decreases in absolute populations, *Heterocephalobus* and *Plectus* being the most stable. Chromadorida increased almost tenfold. Apart from *Pungentus* all Dorylaimida showed increases; the biggest increases were in *Dorylaimus* and *Aporcelaimus*. Overall Mononchida fell from 244,000/m² to 89,000/m².

The situation in Judgeford silt loam reflects both an earthworm effect and the establishment of ryegrass on a subsoil in which the nematode fauna is generally less abundant and diverse (YEATES 1980). Aphelenchoidea, *Heterodera* juveniles, *Helicotylenchus* and *Cephalobus*, all had lower populations in the earthworm inoculated pots, their percentage contribution falling by at least 3%. Although the *Paratylenchus* population fell from 2,526,000—922,000 per m² its percentage contribution increased slightly (42.7—46.2%). In the Dorylaimida, however, *Pungentus, Aporcelaimus* and *Dorylaimellus* all showed actual and percentage increases.

In general terms when earthworms are introduced:

(a) Total nematode populations fell by 37—66%.
(b) The number of taxa recorded was not affected.
(c) Among Tylenchida, there was always an increase in the percentage contribution by *Paratylenchus;* in only one case did absolute abundance increase. Tylenchida generally declined.
(d) Bacterial feeding genera declined, except in Tihoi sand.
(e) Dorylaimida increased markedly, except in Tihoi sand.

Table 1. Analysis of the nematode populations in three soils each of which was represented by earthworm free and earthworm populated samples

Soil type	Tihoi				Wehenga				Judgeford			
Depth sampled (cm)	0—7.4				0—10				0—10			
Earthworms	absent		present		absent		present		absent		present	
Aphelenchus	—		—		—		—		—		18	*0.8*
Aphelenchoidea	27	*3.6*	12	*2.5*	346	*3.3*	206	*3.9*	374	*6.3*	46	*2.3*
Tylenchus	26	*3.5*	13	*2.8*	833	*8.0*	631	*11.9*	22	*0.4*	—	
Cephalenchus	9	*1.2*	6	*1.3*	370	*3.6*	278	*5.2*	—		—	
Ditylenchus	10	*1.3*	130	*27.7*	—		84	*1.6*	—		—	
Pratylenchus	—		—		—		65	*1.2*	46	*0.8*	38	*1.9*
Paratylenchus	22	*2.9*	67	*14.2*	2,804	*26.9*	1,814	*34.4*	2,526	*42.7*	922	*46.2*
Heterodera juv.	19	*2.6*	12	*2.5*	122	*1.2*	107	*2.0*	466	*7.8*	40	*2.1*
Meloidogyne juv.	12	*1.5*	—		—		—		46	*0.8*	18	*0.8*
Helicotylenchus	—		—		—		—		1,208	*20.4*	212	*10.6*
Other Tylenchida	5	*0.7*	2	*0.4*	—		—		—		—	
Rhabditis s. l.	—		26	*5.5*	935	*9.0*	61	*1.1*	10	*0.2*	22	*1.1*
Diplogaster s. l.	—		—		20	*0.2*	—		—		—	
Panagrolaimus	7	*0.9*	33	*7.0*	—		—		—		—	
Cephalobus	134	*17.7*	49	*10.4*	3,008	*28.8*	50	*0.9*	848	*14.3*	156	*7.8*
Heterocephalobus	—		—		428	*4.1*	106	*2.0*	46	*0.8*	18	*0.9*
Other Cephalobidae	—		—		71	*0.7*	—		—		—	
Other Rhabditida	—		6	*1.3*	—		—		—		—	
Teratocephalus	—		—		71	*0.7*	—		—		—	
Plectus	111	*14.8*	6	*1.3*	448	*4.2*	114	*2.2*	—		—	
Anaplectus	—		—		102	*1.0*	—		—		—	
Wilsonema	—		—		51	*0.5*	—		—		—	
Chronogaster	47	*6.3*	—		51	*0.5*	—		—		—	
Chromadorida	—		—		18	*0.2*	175	*3.3*	—		—	
Dorylaimus s. l.	95	*12.6*	28	*5.9*	—		161	*3.0*	—		—	
Dorylaimus s. l.	—		—		20	0.2	120	*2.2*	—		—	
Pungentus	—		—		20	*0.2*	—		76	*1.3*	140	*7.0*
Aporcelaimus	78	*10.4*	76	*16.1*	405	*3.9*	996	*18.9*	246	*4.2*	328	*16.4*
Tylencholaimus	93	*12.4*	4	*0.9*	—		—		—		—	
Dorylaimellus	32	*4.3*	—		—		39	*0.7*	—		40	*2.0*
Falcihasta	—		—		—		8	*0.1*	—		—	
Axonchium	—		—		130	*1.2*	146	*2.8*	—		—	
Alaimidae	—		—		—		50	*0.9*	—		—	
Mononchus	—		—		224	2.1	42	*0.8*	—		—	
Iotonchus	—		—		—		47	*0.9*	—		—	
Cobbonchus	—		—		20	*0.2*	—		—		—	
Other nematodes	25	*3.3*	1	*0.2*	—		—		—		—	
Total nematodes	752		471		10,425		5,299		5,914		1,998	

Note: See text for further details. Nematode abundance (thousands/m²) and the percentage composition of the nematode fauna are given in italics.

4. Discussion

Earthworms are acknowledged to influence the soil environment in regard to: nature of organic matter (enhanced plant growth and decay), chemical composition (particularly plant nutrients), soil structure, soil aeration, soil moisture and microbial populations.

Many of these induced changes may occur in relation to burrows and casts, as has been reported by LOQUET (1978) for CO_2 release and enzymatic activity. It is likely that sites occur where they have no significant direct effect.

In terms of the effect of earthworms on the soil ecosystem, changes must be regarded as all pervading and changes in nematode populations relate to such changes. Explanations for the changes recorded in Table 1 include:

- no significant changes in generic composition occurred when worms were introduced — the same nematodes continue but in different proportions, perhaps their physical habitat remains the same but the cycling of nutrients has changed;
- root-feeding *Paratylenchus* increases, reflecting greater root production and thus available feed;
- bacterial feeders decline — presumably as an earthworm/microbial interaction is playing the predominant role in organic matter breakdown and cycling and earthworms are consuming a significant proportion of the microbial biomass, or its substrate;
- similarly general decline in Tylenchida may reflect a parallel decline in soil fungi as an earthworm/microbial interaction develops;
- increased populations of Dorylaimida may reflect changes in soil structure; also under a differing organic matter regime there may be a swing from a zymogenous fauna (Rhabditida) to an autochthonous fauna (dominated by Dorylaimida; YEATES 1973).

The lack of a consistent pattern of changes in the three soils may reflect the three distinct climatic regimes on the soils. Additional work under more uniform climate may give more uniform results.

The changes found in nematode populations after earthworms become established have many ecological consequences. Firstly, PIEARCE & PHILLIPS (1980) have reported that *Lumbricus terrestris* fed on cattle dung rich in nematodes had active nematodes in the pharyngeal and oesophageal regions although none were recorded from the much greater quantities of material present in crops and gizzards, and in faeces. Apparently nematodes were making a contribution to the nutrition of *L. terrestris*, as has been reported by *Lampito mauritii* by DASH et al. (1980). Secondly, effluent irrigation on grazed pasture resulted in a threefold increase in earthworm number and biomass (YEATES 1976); under the same circumstances the total nematode population increased only 1.2 times (YEATES 1978b). With the results reported in the present paper it is likely that the increased earthworm population reported by YEATES (1976) had a significant effect in reducing the nematode standing crop. Thirdly, grazing by Collembola damaged 6.9% of *Heterodera* cysts (MURPHY & DONCASTER 1957). The overall reduction by earthworms reported here may have a significant influence on the damage caused by economically important nematodes.

Further studies are needed to extend these findings and clarify whether plant feeding nematodes in the rhizosphere are as prone to ingestion as saprophages in the soil as a whole. It appears increased earthworm populations may lead to decreased standing crops of other components of the soil microfauna, including soil nematodes. The implications of these changes for nutrient cycling and nematode control need investigation.

5. Acknowledgements

Samples were collected by JOHN SMALL, MARY DUTCH, Drs. J. D. STOUT and D. C. COLEMAN; slides were made by DIANA GABRIC and RUTH SPENCER.

6. Summary · Zusammenfassung

European Lumbricidae are widespread in New Zealand pastures and increase their productivity. In two field trials and one glasshouse trial nematode populations have been sampled in earthworm free and earthworm inoculated treatments. The total soil nematode population was reduced by

37—66 % in inoculated treatments. Changes in generic populations were not consistent, possibly due to climatic factors, but the overall changes are assumed to reflect changes in patterns of decomposition and nutrient cycling. Further ecosystems need to be investigated to determine how widespread such changes are, and whether they also affect other mesofauna.

Bodennematoden-Besatz in Gegenwart von Regenwürmern unterdrückt

Europäische Lumbriciden sind in neuseeländischen Grünlandböden weit verbreitet, und ihre Produktivität nimmt zu. In zwei Feldversuchen und einem Glashausexperiment wurden Nematodenpopulationen in regenwurmfreien und mit Regenwürmern besiedelten Parzellen untersucht. Der gesamte Nematodenbesatz wurde in den mit Regenwürmern besiedelten Parzellen um 37—66% verringert. Auf dem Gattungsniveau ergaben sich keine qualitativen Veränderungen des Nematodenbesatzes, möglicherweise infolge der klimatischen Einflüsse, doch die Gesamtänderungen des Besatzes reflektieren vermutlich Änderungen der Abbauprozesse und des Nährstoffkreislaufs. Weitere Ökosysteme müßten untersucht werden, um zu bestimmen, wie verbreitet derartige Änderungen sind und ob diese auch andere Komponenten der Mesofauna betreffen.

7. Literature

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